(12) **EUROPEAN PATENT APPLICATION**

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(54) **Method of synthesizing optical images.**

(57)   A method and apparatus for forming a syn-
thesized optical image with all of the desired
objects in focus. A prescribed number of optical
images of the same scene are provided by
recording an optical image at a respective focal
distance and changing the focal distance for
each additional optical image as recorded. The
optical images are subjected to wavelet trans-
formation to form a multi-resolution represen-
tation. The coefficients of the various
multi-resolution representations are compared
at the same position to detect the maximum
spectral amplitudes. Based on the detected
maximum spectral amplitudes, another multi-
resolution representation is obtained. Then, an
inverse wavelet transformation is performed to
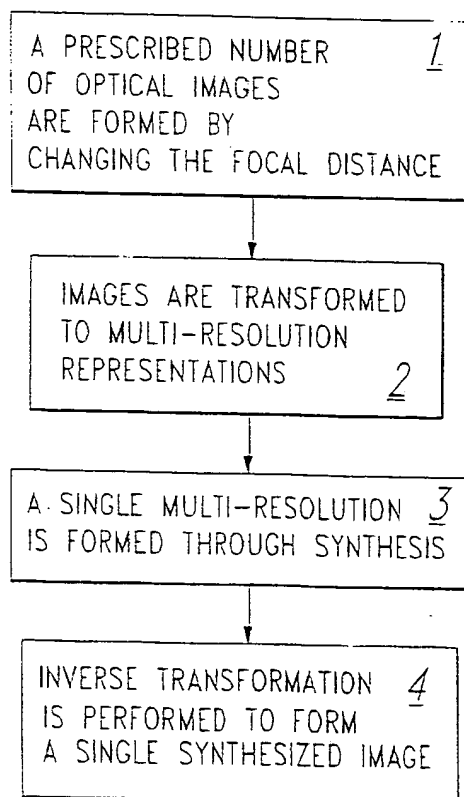obtain the synthesized optical image.

```
┌─────────────────────────────────────┐
│ A PRESCRIBED NUMBER          1       │
│ OF OPTICAL IMAGES                    │
│ ARE FORMED BY                        │
│ CHANGING THE FOCAL DISTANCE          │
└─────────────────────────────────────┘
                  │
                  ▼
┌─────────────────────────────────────┐
│ IMAGES ARE TRANSFORMED               │
│ TO MULTI-RESOLUTION                  │
│ REPRESENTATIONS          2           │
└─────────────────────────────────────┘
                  │
                  ▼
┌─────────────────────────────────────┐
│ A SINGLE MULTI-RESOLUTION  3         │
│ IS FORMED THROUGH SYNTHESIS          │
└─────────────────────────────────────┘
                  │
                  ▼
┌─────────────────────────────────────┐
│ INVERSE TRANSFORMATION     4         │
│ IS PERFORMED TO FORM                 │
│ A SINGLE SYNTHESIZED IMAGE           │
└─────────────────────────────────────┘
```

Fig. 1

EP 0 629 964 A1

This invention concerns a method for synthesizing optical images. More specifically, this invention concerns a method for synthesizing multiple optical images obtained by changing the focal distance.

BACKGROUND OF THE INVENTION

When a camera is used to record optical images and objects relatively far from the camera lens are in focus, objects nearer to the camera lens are out of focus and their recorded images are blurred. On the other hand, when focusing on the nearer objects, the farther objects are out of focus and their recorded images are blurred. This problem is believed to be related to the intrinsic characteristics of the optical system. According to a basic optical principle, a pinhole lens has an infinite focal depth, and all objects are in focus when their images are recorded within the pinhole lens of a pinhole camera. However, for the [ideal] pinhole lens, the hole is so small that not even a single photon can pass through it, and hence no image is formed. That is, it is merely a hypothetical lens.

Due to this basic physical limitation, the lens has a finite focal depth, and the picture of the object is taken by means of automatic or manual focusing. However, when two objects, one nearer the camera and the other farther away from it, are to be photographed in the same picture, it is impossible to bring both into focus at the same time. That is, while bringing one object into focus, the other goes out of focus and its image becomes blurred. This is a disadvantage.

Although not a technology for forming a synthesized image, a technology known as inverse filtering has been tested which attempts to create a clear image from the blurred portion of a picked-up image by means of enhancing the blurred portion. However, since it also amplifies noise, it fails to reach the stage of practical applications.

OBJECT OF THIS INVENTION

An object of this invention is to provide a method for forming a synthesized image in which multiple optical images picked up at different focal distances are in focus in the synthesized image.

SUMMARY OF THE INVENTION

This invention provides a method for obtaining a synthesized image while bringing objects at different positions into focus by means of digital signal processing using multiple image representations. According to one aspect of the invention there is provided a method for synthesizing transformations from various image element signals of multiple optical images added at different focal distances to obtain multi-resolution aforementioned optical images; comparing the various coefficients of the aforementioned optical

images at the same position so as to detect the maximum spectral amplitude detected at each of the aforementioned prescribed positions; and forming the image element signals from the aforementioned synthesized multi-resolution

According to another aspect there is provided imaging apparatus for forming a synthesized image from all objects in a field of view (FOV) comprising:- image capturing means capable of forming a focused image of one or more objects in the field of view; memory means for stored the focused images; and image synthesizing means for synthesizing an image of the or each object in the field of view from the stored focused images.

Reference will now be made by way of example to the accompanying drawings, in which:-

Fig 1 is a flow chart illustrating an embodiment of a method for synthesizing optical images in accordance with the present invention.

Fig 2 is a block diagram illustrating an embodiment of an apparatus for implementing the method of synthesizing optical images in accordance with the present invention.

Figure 3 is a block diagram illustrating another embodiment of an apparatus for implementing the method for synthesizing optical images in accordance with the present invention.

Figure 4 is a schematic diagram illustrating an embodiment for implementing multi-resolution representation in accordance with the invention.

Figure 5 is a photograph taken with a camera lens system picking up and focusing on a nearby object.

Figure 6 is a photograph of the same scene shown in Figure 5, but with the camera lens system picking up and focusing on a remote object.

Figure 7 is a diagram illustrating a multi-resolution representation of the optical image shown in Figure 5 as an embodiment of this invention.

Figure 8 is a diagram illustrating a multi-resolution representation of the optical image shown in Figure 6 as an embodiment of this invention.

Figure 9 is a synthesized photograph of the same scene shown in Figures 5 and 6, but illustrating a synthesized optical image in accordance with the present invention.

Figure 10 is a diagram illustrating a portion of the program in an embodiment of the forward transformation of a multi-resolution representation in accordance with the invention.

Figure 11 is a diagram illustrating a portion of the program in an embodiment of the forward transformation of a multi-resolution representation in accordance with the invention.

Figure 12 is a diagram illustrating a portion of the program in an embodiment of the inverse transformation of a multi-resolution representation in accordance with the invention.

Figure 13 is a diagram illustrating a portion of the

program in an embodiment of the inverse transformation of a multi-resolution representation in accordance with the invention.

In reference numerals as shown in the drawings:

10, image device
20, pickup device
30, synthesis device
40, frame memory
I, synthesized image

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Figure 1 is a flow chart illustrating an embodiment of a method for synthesizing an optical image in accordance with the invention. First of all, multiple optical images are formed at respective different focal distances by changing the focal distance of the camera lens (step 1). It is possible to adjust the focal distance either linearly or nonlinearly in the range from infinity to zero. However, there is virtually no problem in specifying the focal distance itself. It is only necessary to focus to the extent to which all objects to be brought into focus can be extracted. An appropriate number of images are picked up in this step.

Then, the picked-up images are transformed to the multi-resolution representation (step 2). This multi-resolution representation is based on the multi-resolution technology discussed recently in mathematics (see: C. H. Chui: "An introduction to wavelets;" I. Daubechies: "Orthonormal bases of compactly supported wavelets." Communication of pure and applied mathematics, Vol. XLI 909-996 (1988)). Generally speaking, it is an isolation technology, in which, by means of special filtering and subsampling, the original signals are isolated into high-frequency and low-frequency components without increasing the total amount of data. A prominent feature of this isolation technology is that the aforementioned low-frequency component can be further isolated using the same filtering method. In this way, the operation can be repeated for the required number of cycles for the specific application. The layered signal representation in the frequency region generated in this way is usually called multi-resolution representation.

Then, the transformed multi-resolution representations are synthesized to form another new multi-resolution representation (step 3), followed by inverse multi-resolution representation to form the synthesized image (step 4). That is, the multiple multi-resolution representations corresponding to the images in focus at different distances are synthesized to form another multi-resolution representation, which is then subjected to an inverse transformation to obtain a synthesized image in which the various objects are optimally in focus.

Figure 2 is a diagram illustrating an example of the image equipment apparatus for implementing the method of this invention. In this example, the method and equipment for forming a synthesized image I for which optimal focusing is realized for all of the objects, from object A, nearest to the image equipment 10 to object Z, farthest away from it. Pickup device 20 first focuses on object A (with the shortest focal distance) and its optical image (image I_A) is recorded via a CCD (not shown in Figure 2) in frame memory 40. Then, the pickup device 20 focuses on object B (with the focal distance increased slightly), and its image is recorded in another frame memory (or on another region in the same frame memory). In the same way, the operation is performed in order until focusing of the most remote object Z (with focal distance up to infinity) is performed, and its image I_Z is recorded in the corresponding frame memory. (For the various objects, there is no need to record A in I_A, B in I_B, etc., they may be matched to I_n (n = A, ..., Z) in any [order]. However, in the present example, it is assumed that A is focused to form I_A, B is focused to form I_B, ...) Focusing for objects A-Z is carried out by means of the control signals from synthesis device 30. However, it may also be performed manually or by means of other control equipment. The order in which the images are picked up can be selected at will. The method to be explained later is used to synthesize images I_A-I_Z recorded in the various frame memories by means of synthesis device 30, forming synthesized image I. The memory may be in the form of a magnetic memory or an optical memory. It is also possible to input the picked-up signals into synthesis device 30. Also, photoelectric conversion equipment other than a CCD may be used as well.

Figure 3 illustrates another embodiment of the apparatus. It differs from the case shown in Figure 2 in that it has multiple pickup devices. For simplicity, only two pickup devices 20 and 25 are shown in Figure 3. The input optical information is equally divided between half-mirror 40 and mirror 50, and the portions are input into pickup device 20 and pickup device 25, respectively. Consequently, one of the pickup devices 20 or 25 focuses on object A (with a shorter focal distance) to add image I_A, which is then recorded in frame memory 40. Then the other pickup device focuses on object B (with a longer focal distance) to capture image I_B, which is recorded in frame memory 45. Then, by using a method to be explained later, an image I, which corresponds to the optimal focusing for both objects A and B, is formed by means of a synthesis device 30.

In the following, the multi-resolution representation using the wavelet coefficients executed by synthesis device 30 will be explained. As shown in Figure 4, image element signal A from the frame memory is isolated into four wavelet transformations a, b, c, and d by means of a hierarchical filter bank. Filters H and G correspond to high-pass and low-pass filters, respectively, and are complementary to each other

(mirror filters). Filters G and H are called wavelet filters when filtering and subsampling (blocks indicated by arrows) to form the orthogonal isolation of the input signal. Figure 4 is a diagram illustrating the case of 3-layer isolation of the signal by means of one-dimensional (in either the horizontal or vertical direction) filtering. For the 2-dimensional filtering adopted in this invention, sequential filtering is performed in the horizontal and vertical directions. That is, after execution of filtering in the horizontal direction (or vertical direction), filtering in the vertical direction (or horizontal direction) is executed in this configuration.

Although a frequency domain representation, the multi-resolution representation also has spatial information (information related to position). On the other hand, for the Fourier transform, although a good representation in the frequency domain can be realized, no spatial information can be preserved; hence, the position cannot be specified (the uncertainty principle).

Next, the synthesis of multi-resolution images by means of multi-resolution representation will be explained. The multi-resolution representation using wavelet transformation is a representation of the input signal in the frequency domain. This representation also represents spatial information at the same time. In the multi-focus synthesis method, N multiple input images recorded for the same scene followed by wavelet transformation are the objects, and the wavelet coefficients that represent the most intense high-frequency component at each image element position are selected, since they are taken as the representation of the focal image at the aforementioned position. This process is executed for all of the image element positions of the image. By means of synthesis of the image elements selected for one multi-resolution representation detected at each position, a new multi-resolution representation can be formed with all of the image elements optimally focused. If needed, the aforementioned process may be not implemented for the lowest position at which the wavelet coefficients have almost the same value.

On the other hand, for the aforementioned synthesis, it is necessary to evaluate the spectral distribution of the image by changing the focal distance. Consequently, the Fourier transform of the overall image or partial small blocks (such as the cosine transform method used as a basic technology of image compression) may be considered. However, in this approach, the spectral lines and ends of lines usually expand into multiple coefficients, and this phenomenon makes the frequency and position information unclear. Consequently, in the wavelet transformation, these two types of information are preserved, and hence it is basically appropriate for use in the multi-focus synthesis method.

Figure 5 is a photograph which illustrates the optical image provided by focusing on a nearby cup. Figure 6 is a photograph which illustrates the optical image provided by focusing on a remote tree in the same scene shown in Figure 5. Figures 7 and 8 show the multi-resolution representations for the images of Figures 5 and 6, respectively. For Figures 5 and 6, the original image is represented by means of 704 pixels x 480 lines. They are isolated into 5 frequency bands shown in Figures 7 and 8. In the 2-dimensional multi-resolution representation, the lower right corresponds to the higher frequency components. The lowest layer (the upper left corner) corresponds to the lowest frequency components, and it can be taken as the image which can pass through the lowest low-pass filter (and subsampled).

In the case of multi-focus synthesis, the scenes of the same image are photographed for the desired number of cycles by a camera (or multiple cameras) at different focal distances. However, for the lowest layer generated by the lowest low-pass filtering operation, even when photographing at different focal distances, the images obtained are still almost identical. (In other words, it is preferred that the number of layers be set to make the lowest frequency layers almost identical). The lowest frequency layer represents the mean brightness of the image.

On the other hand, for the higher frequency layers, the higher spectral components appear at various positions in the multi-resolution representation, and they correspond well to the objects in focus at the various focal distances.

Consequently, when the multi-resolution representation is adopted, the following takes place:

(1) In the lowest frequency layer (the 15 pixel x 22 lines on the upper left corner in Figures 7 and 8), each coefficient is derived as an average of multiple input images, or by extraction from the coefficients of a prescribed image. It is used as the lowest frequency layer of the synthesized image.

(2) For the upper layers, at each position, there is a multi-resolution representation that gives the maximum spectral amplitude (maximum absolute value). That is, for the multi-resolution representation that gives the maximum spectral amplitude at position of i, j, as the simplest method,

$$\max(|A_{i,j}^{(1)}|, |A_{i,j}^{(2)}|, ... |A_{i,j}^{(N)}|) \quad (1)$$

is used as the representation (N = number of the multi-resolution representation, that is, number of the optical images added). It corresponds to the optimal focusing of the input scene, and the corresponding multi-resolution coefficients give the information. The overall multi-resolution representation is formed according to this rule. In this way, at all of the positions, the multi-resolution representations that give the maximum spectral amplitude are detected, and they are synthesized to form the new multi-resolution representation. This rule itself is believed to have various forms.

Then, based on the detected maximum spectral amplitude position, an inverse multi-resolution transformation is performed so that the synthesized multi-resolution representation is transformed to an optical image composed of image element signals. As shown in Figure 9, this optical image is a synthesized image of a nearby cup and a far away tree, both of which are well in focus in the picture.

Although not directly related to this invention, depending on the method of synthesis, there are cases in which the frame sizes may differ. This is an influence of the zoom effect as related to focusing of the various optical images. If needed, the size may be changed using various adjustment methods, such as "enlargement," "contraction," "interpolation," "extraction," etc., before the synthesis operation.

Figures 10-13 illustrate portions of the program for the forward and inverse wavelet multi-resolution transforms.

The aforementioned synthesis method does not depend on the image techniques related to content, such as edge extraction, texture analysis, etc. The present method for synthesizing is completely different from methods with any precondition related to 3-dimensional objects. It is a method in which a stable synthesized result can be obtained with respect to all natural images. (That is, there is absolutely no generation of significant degradation in the case when the precondition is violated.) In addition, the edge analysis is still in the stage of initial development. When the number of edges is increased, the processing time increases exponentially. Consequently, it has not been used in practical applications. At present, the present method is the most appropriate method for practical applications for natural images.

Also, since it is based on detection of the maximum spectral amplitude from the multiple multi-resolution coefficients, there is no limitation to the number of optical images which can be added. By capturing multiple optical images, it is possible to obtain a synthesized image that is in focus at almost all positions. Also, enlargement is possible to obtain very correct 3-D information (distance, appearance of object, etc.)

In the above description, embodiments of this invention have been presented. However, this invention is not limited to these embodiments. This invention can be used with various types of equipment, such as cameras, television cameras, monitoring cameras, medical imaging cameras, etc.

This invention provides an effective method for forming a single synthesized optical image from multiple optical images added at different focal distances, with optimal focusing.

Claims

1. A method for synthesizing optical images com-

prising of the following steps: performing wavelet transformations from various image element signals of multiple optical images added at different focal distances to obtain multi-resolution representations with a number corresponding to the number of the aforementioned optical images.; comparing the various coefficients of the aforementioned multi-resolution representations corresponding to the aforementioned optical images at the same position so as to detect the maximum spectral amplitude at each of the prescribed positions; and forming the image element signals from the aforementioned synthesized multi-resolution representation by means of inverse wavelet transformation.

2. Imaging apparatus for forming a synthesized image from all objects in a field of view; memory means for storing the focused images; and image synthesizing means for synthesizing an image of the or each object in the field of view from the stored focused images.

3. The Apparatus of claim 2, wherein the image synthesizing means comprise one or more filters.

4. The Apparatus of claim 3, wherein the filters form a hierarcical filter bank comprising low-pass and high-pass filters.

5. The apparatus of any claims 2 to 4, wherein the image capturing means comprise a single device and image capture of each object occurs sequentially.

6. The Apparatus of claim 5, wherein the image capturing means captures the image from the closest object first and the farthest object last.

7. The Apparatus of any of claims 2 to 4, wherein the image capturing means plurality of devices each adapted to capture the image of a different object in the field of view.

8. The Apparatus of any of claims 2 to 7, wherein the memory means comprise a frame memory for storing the image formed from the or each image capturing means.

9. Apparatus for carrying out the method of claim 1.

A PRESCRIBED NUMBER   *1*
OF OPTICAL IMAGES
ARE FORMED BY
CHANGING THE FOCAL DISTANCE

↓

IMAGES ARE TRANSFORMED
TO MULTI-RESOLUTION
REPRESENTATIONS   *2*

↓

A SINGLE MULTI-RESOLUTION   *3*
IS FORMED THROUGH SYNTHESIS

↓

INVERSE TRANSFORMATION   *4*
IS PERFORMED TO FORM
A SINGLE SYNTHESIZED IMAGE

Fig. 1

FOCUS
CONTROL
SIGNAL

MAXIMUM FOCAL DISTANCE

MEDIUM FOCAL DISTANCE

MINIMUM FOCAL DISTANCE

~20

~40

I_z

I_A

~30

SYNTHESIS DEVICE

I

Fig. 2

6

Fig. 3

Fig. 4
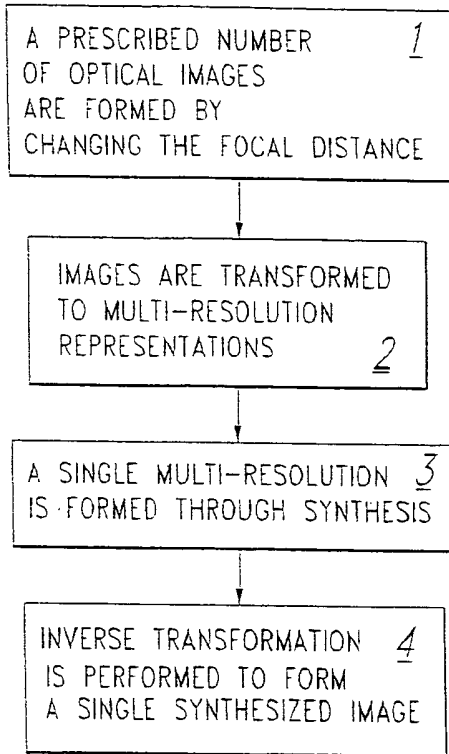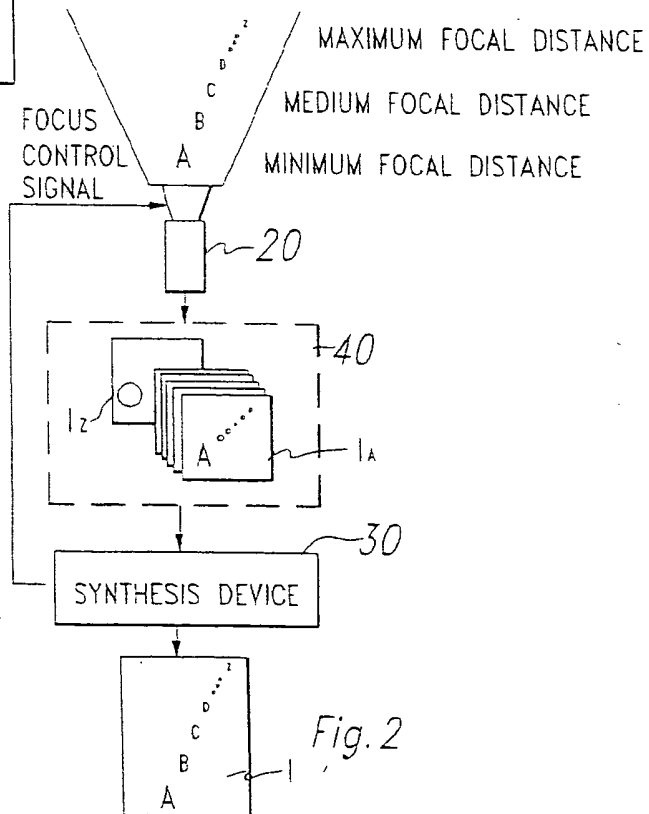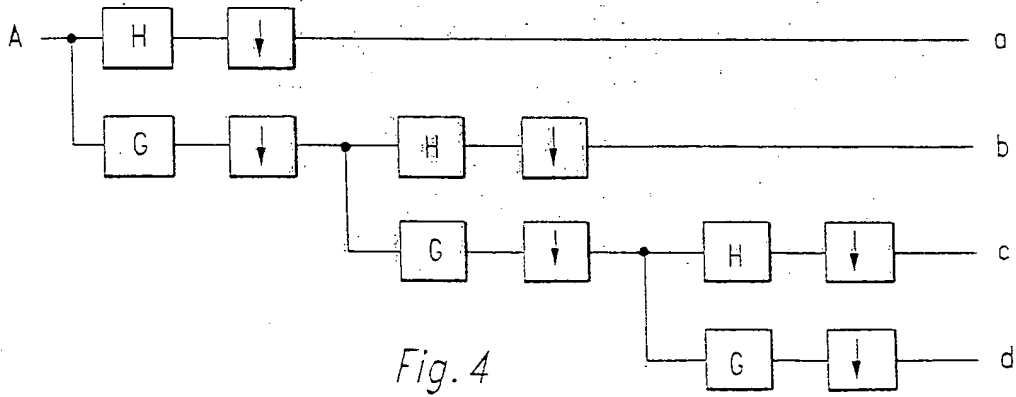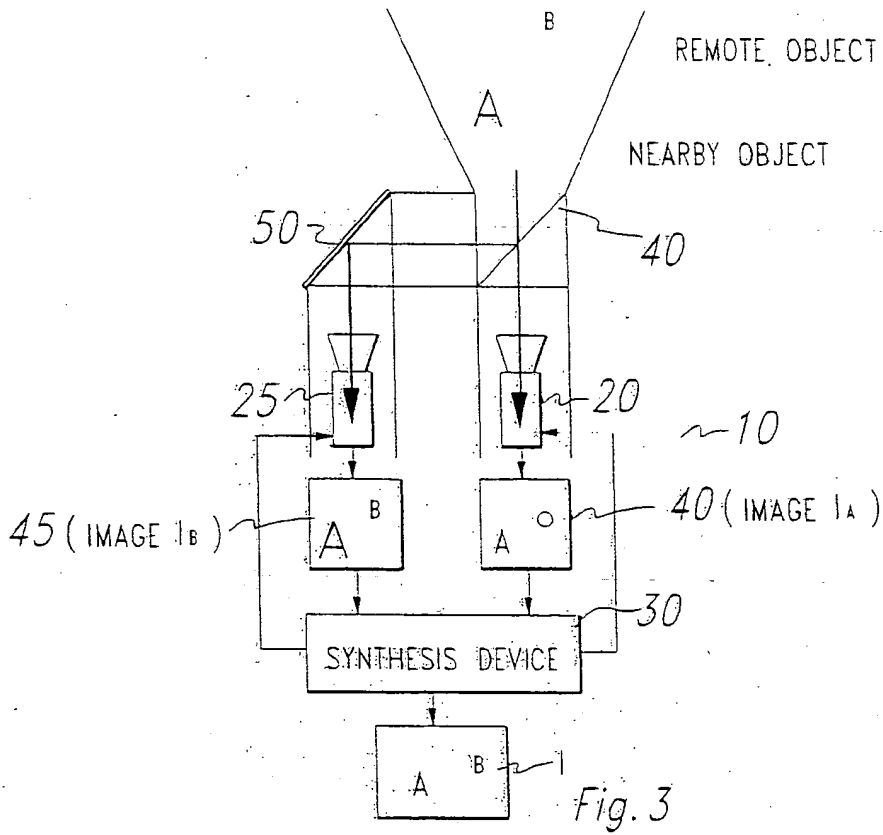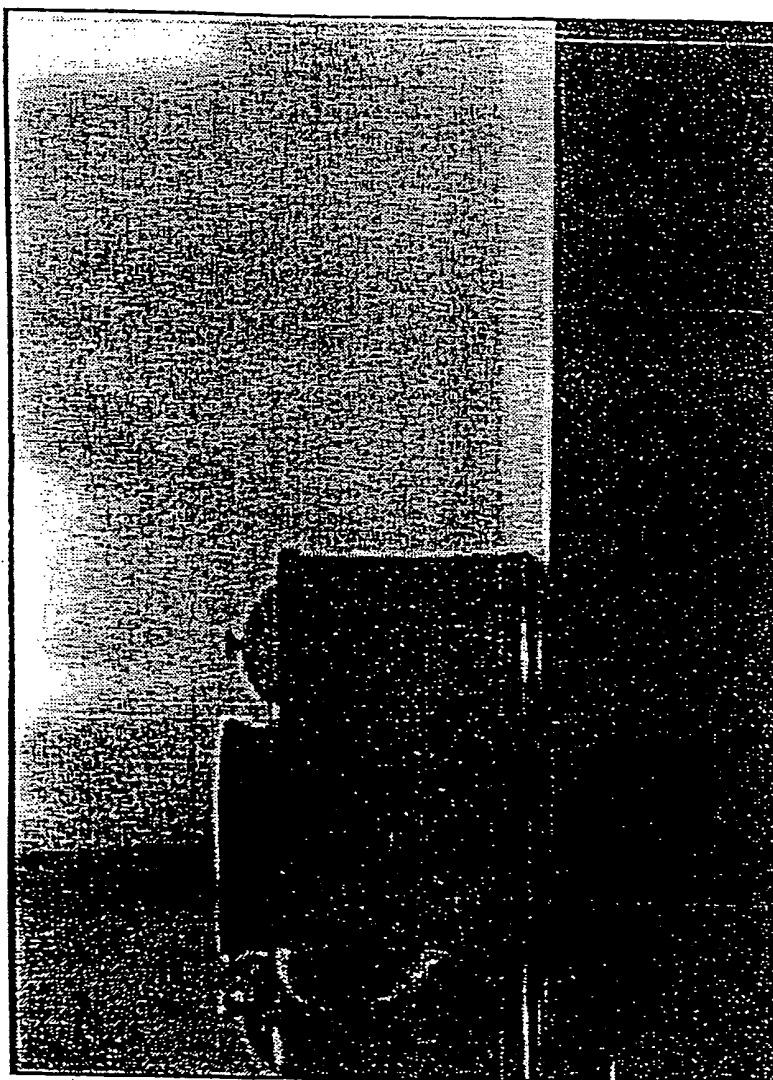
Fig. 5
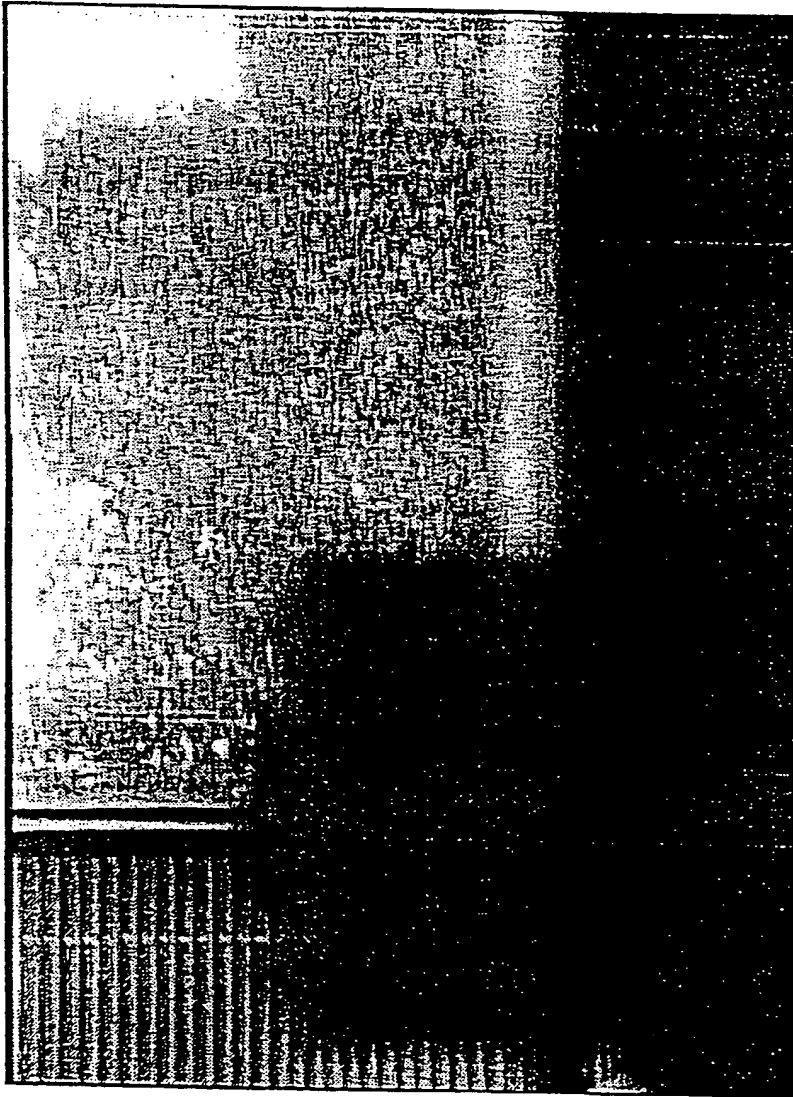
Fig. 6
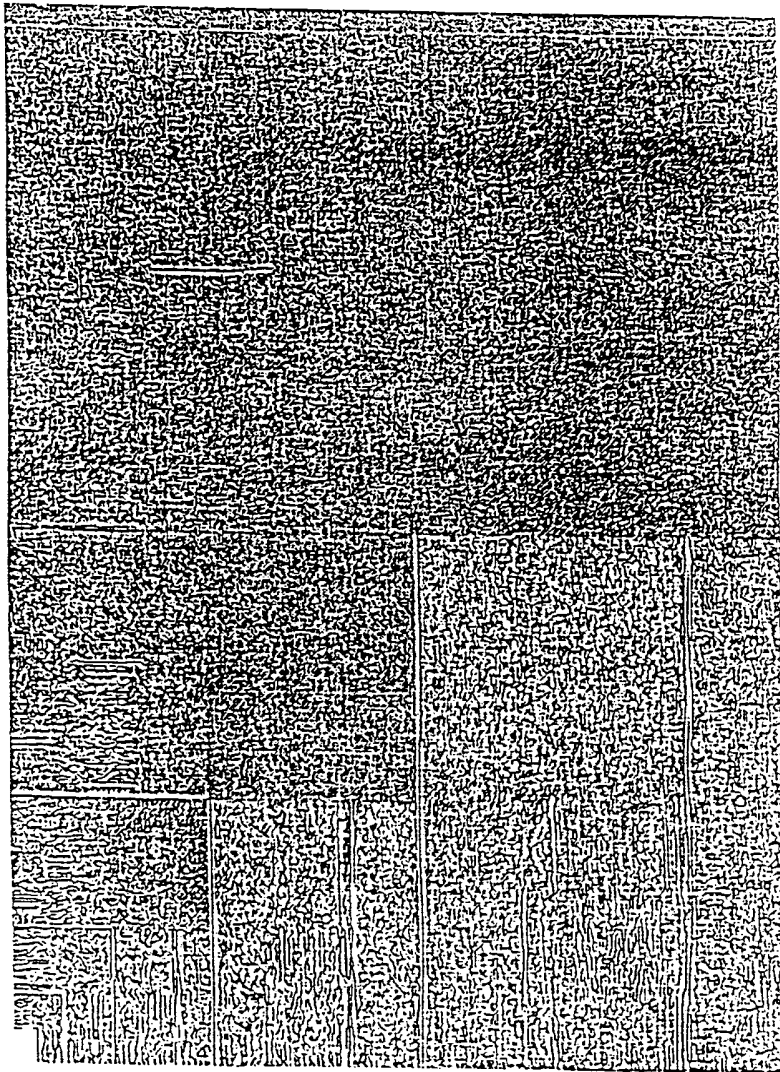
Fig. 7
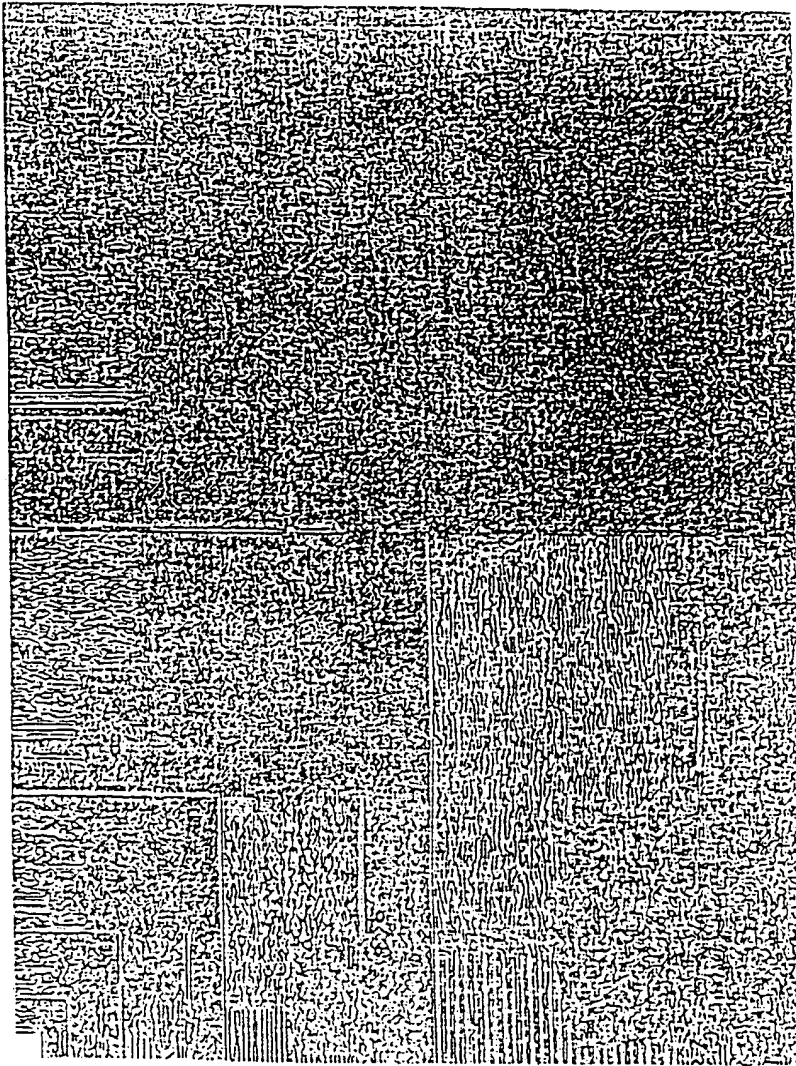
Fig. 8
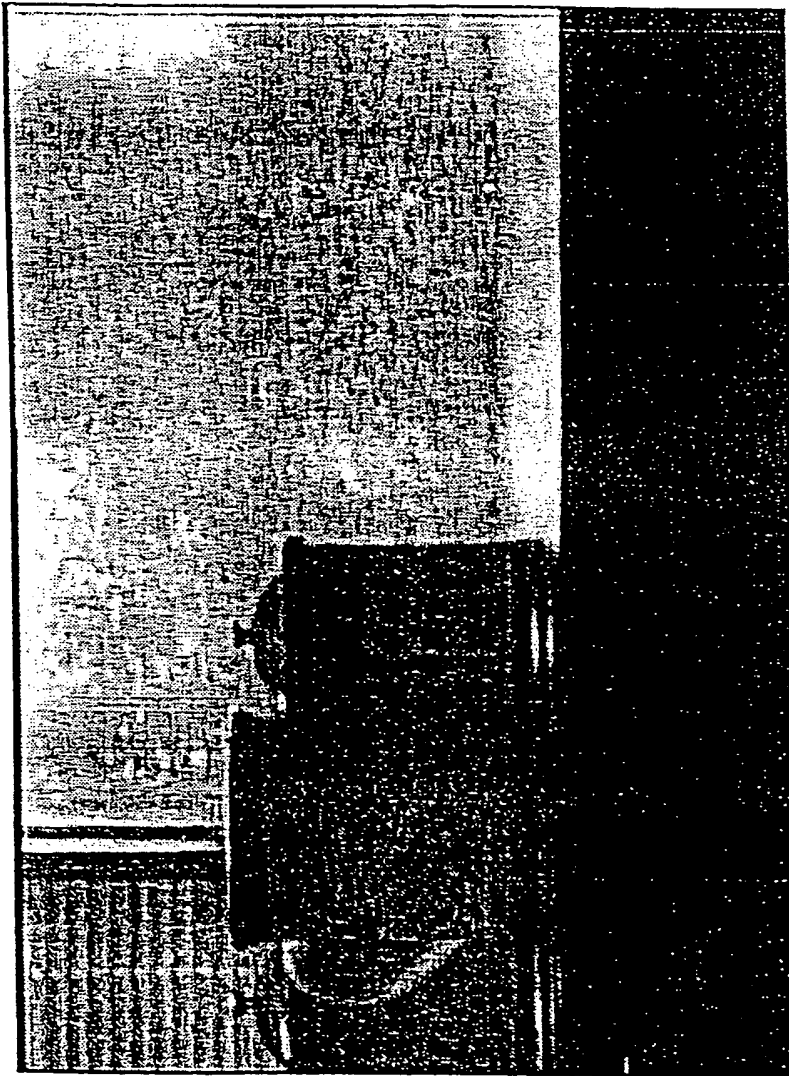
Fig. 9

Fig. 10a

```
/**************************************************/
/* Forward Wavelet Transform                      */
/*    This subroutine performs the N=3 Daubichies */
/*    forward wavelet transform on image defined  */
/*    as global variable "short YYcomponent".     */
/*    The transformed results are stored back in  */
/*    "YYcomponent".                              */
/*                                                */
/*    11/20/1992                                  */
/*    Texas Instruments video/SIS/TRDC (Yamaguchi)*/
/**************************************************/

ForwardWavelet(short YYcomponent[4][500][720], int Vsize, int Hsize, int layers, int component )
{
short TEMPcomponent[500][720];

double HCoeff[11]={0,0,0,0, 0.33670552950, 0.806891509311, 0.459877502118,
                  -0.13501102001O, -0.085441273882, 0.035226291882, 0);
                  /*This is Daubichies filter of N=3 */
double GCoeff[11]={0, 0.035226291882, 0.085441273882, -0.13501102001O, -0.459877502118,
                  0.806891509311, -0.33670552950, 0, 0, 0, 0);

register i,j,k;
int inttemp;
int refV, refH;
int resolution;

for (i=0;i<11;i++)
    {
```

Fig. 10b

```
HCoeff[i]/=sqrt(2.0);
GCoeff[i]/=sqrt(2.0);
}

for (resolution=0;resolution<=layers-1;resolution++)
{
    for (refV=0;refV<Vsize;refV++) for (refH=0;refH<Hsize;refH+=2)
    {
        inttemp=0;
        for (i=-5;i<=5;i++)
        {
            if (refH+i<0) inttemp+=YYcomponent[component][refV][-(refH+i)]*HCoeff[5-i];
            else if ((refH+i)>=(Hsize-1))
                inttemp+=YYcomponent[component][refV][(Hsize-1)*2-(refH+i)]*HCoeff[5-i];
            else inttemp+=YYcomponent[component][refV][refH+i]*HCoeff[5-i];
        }
        TEMPcomponent[refV][refH/2]=inttemp;

        inttemp=0;
        for (i=-5;i<=5;i++)
        {
            if (refH+i<0) inttemp+=YYcomponent[component][refV][-(refH+i)]*GCoeff[5-i];
            else if ((refH+i)>=(Hsize-1))
                inttemp+=YYcomponent[component][refV][(Hsize-1)*2-(refH+i)]*GCoeff[5-i];
            else inttemp+=YYcomponent[component][refV][refH+i]*GCoeff[5-i];
        }
        TEMPcomponent[refV][Hsize/2+refH/2]=inttemp;
    }

    for (refV=0;refV<Vsize;refV+=2) for (refH=0;refH<Hsize;refH++)
    {
        inttemp=0;
        for (i=-5;i<=5;i++)
```

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Fig. 11

```
            {
            if (refv+i<0) inttemp+=TEMPcomponent[-(refv+i)][refH]*Hcoeff[5-i];
            else if ((refv+i)>=(Vsize-1))
                inttemp+=TEMPcomponent[(Vsize-1)*2-(refv+i)][refH]*Hcoeff[5-i];
            else inttemp+=TEMPcomponent[refv+i][refH]*Hcoeff[5-i];
            }
        YYcomponent[component][refv/2][refH]=inttemp;

        inttemp=0;
        for (i=-5;i<=5;i++)
            {
            if (refv+i<0) inttemp+=TEMPcomponent[-(refv+i)][refH]*Gcoeff[5-i];
            else if ((refv+i)>=(Vsize-1))
                inttemp+=TEMPcomponent[(Vsize-1)*2-(refv+i)][refH]*Gcoeff[5-i];
            else inttemp+=TEMPcomponent[refv+i][refH]*Gcoeff[5-i];
            }
        YYcomponent[component][Vsize/2+refv/2][refH]=inttemp;
        }

    Hsize=Hsize/2; Vsize=Vsize/2;
```

Fig. 12a

```
/**********************************************************/
/*  Inverse Wavelet Transform                           */
/*    This subroutine performs the N=3 Daubichies       */
/*    inverse wavelet transform on image defined        */
/*    as global variable "short YYcomponent".           */
/*    The transformed results are stored back in        */
/*    "YYcomponent".                                    */
/*                                                      */
/*    7/30/1992                                         */
/*    Texas Instruments video/SIS/TRDC (Yamaguchi)      */
/**********************************************************/

InverseWavelet(short YYcomponent[4][500][720], int Vsize, int Hsize, int layers, int component)
{

double HCoeff[11]={0,0,0,0,0, 0.33670552950, 0.80689150931l, 0.459877502118,
                   -0.13501102001O, -0.085441273882, 0.03522629l882};
                   /*This is Daubichies filter of N=3 */
double GCoeff[11]={0, 0.03522629l882, 0.085441273882, -0.13501102001O, -0.459877502118,
                   0.80689150931l, -0.33670552950, 0, 0, 0, 0};

register i,j,k;
int inttemp1, inttemp2;
int refV, refH;

int resolution;

short YYtemp1[500][720];
short YYtemp2[500][720];

for (i=0;i<11;i++)
  {
  HCoeff[i]*=sqrt(2.0);
  GCoeff[i]*=sqrt(2.0);
```

Fig. 12b

```
for (resolution=0;resolution<=layers-1;resolution++)
{
for (refv=0;refv<Vsize*2;refv++) for (refH=0;refH<Hsize;refH++)
{
  YYtemp1[refv][refH*2]=YYcomponent[component][refv][refH];
  YYtemp1[refv][refH*2+1]=0
  YYtemp2[refv][refH*2]=YYcomponent[component][refv][Hsize+refH];
  YYtemp2[refv][refH*2+1]=0
}
for (refv=0;refv<Vsize*2;refv++) for (refH=0;refH<Hsize*2;refH++)
{
  inttemp1=0; inttemp2=0;
  for (i=-5;i<=5;i++)
  {
    if (refH+i<0))
    {
      inttemp1+=YYtemp1[refv][-(refH+i)]*Hcoeff[5+i];
      inttemp2+=YYtemp2[refv][-(refH+i)]*Gcoeff[5+i];
    }
    else if ((refH+i)>=(Hsize*2-1))
    {
      inttemp1+=YYtemp1[refv][(Hsize*2-1)*2-(refH+i)]*Hcoeff[5+i];
      inttemp2+=YYtemp2[refv][(Hsize*2-1)*2-(refH+i)]*Gcoeff[5+i];
    }
    else
    {
      inttemp1+=YYtemp1[refv][refH+i]*Hcoeff[5+i];
      inttemp2+=YYtemp2[refv][refH+i]*Gcoeff[5+i];
    }
  }
  YYcomponent[component][refv][refH]=inttemp1+inttemp2;
```

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Fig. 13

```
for (refV=0;refV<Vsize;refV++) for (refH=0;refH<Hsize*2;refH++)
{
    YYtemp1[refV*2][refH]=YYcomponent[component][refV][refH];
    YYtemp1[refV*2+1][refH]=0
    YYtemp2[refV*2][refH]=YYcomponent[component][Vsize+refV][refH];
    YYtemp2[refV*2+1][refH]=0
}
for (refV=0;refV<Vsize*2;refV++) for (refH=0;refH<Hsize*2;refH++)
{
    inttemp1=0; inttemp2=0;
    for (i=-5;i<=5;i++)
    {
        if (refV+i<0))
        {
            inttemp1+=YYtemp1[-(refV+i)][refH]*Hcoeff[5+i];
            inttemp2+=YYtemp2[-(refV+i)][refH]*Gcoeff[5+i];
        }
        else if ((refV+i)>(Vsize*2-1))
        {
            inttemp1+=YYtemp1[(Vsize*2-1)*2-(refV+i)][refH]*Hcoeff[5+i];
            inttemp2+=YYtemp2[(Vsize*2-1)*2-(refV+i)][refH]*Gcoeff[5+i];
        }
        else
        {
            inttemp1+=YYtemp1[refV+i][refH]*Hcoeff[5+i];
            inttemp2+=YYtemp2[refV+i][refH]*Gcoeff[5+i];
        }
    }
    YYcomponent[component][refV][refH]=inttemp1+inttemp2;
}
Hsize*=2; Vsize*=2;
}
```

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European Patent
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EUROPEAN SEARCH REPORT

Application Number

EP 94 30 0605

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
X	US-A-5 124 842 (HONDA ET AL.) * column 3, line 39 - line 68 * * column 4, line 31 - line 61; figures 1,2 *	1-3,5-9	G06F15/68
A	WO-A-85 04036 (FERREN, BRAN) * page 3, line 16 - line 34 * * page 4, line 20 - line 33 * * page 5, line 36 - page 6, line 4 * * page 13, line 24 - page 14, line 36 *	1-9	
			TECHNICAL FIELDS SEARCHED (Int.Cl.5)
			G06F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	26 May 1994	Gonzalez Ordonez, O

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